A Comprehensive Study on the Use of AI-driven Autonomous Systems in Dynamic Environments for Military Applications

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Motivation

- How can we better understand the topology of the dynamic operational environment?
- How can we leverage AI-driven robotic/autonomous systems for automated remote target detection and decision support in dynamic battle environments?
- Need for reliability and feasibility studies on the utility of AI/ML-driven autonomous vehicles as critical decision support systems for better terrain mapping and enhanced mission success goals.

Challenges: Man Vs. Machine

MAN

TERRAIN MAPPING

DECISION MAKING

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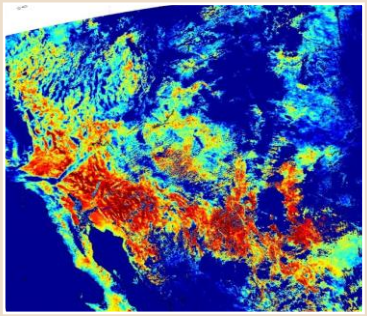
Role of AI-driven Autonomous vehicles

DRONES

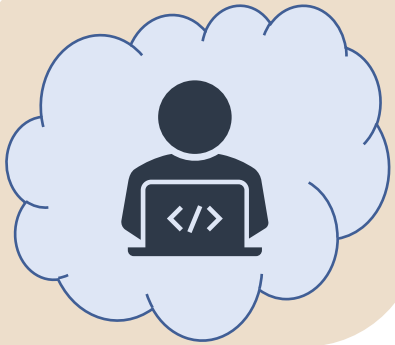


TERRAIN MAPPING

TARGETS OF INTEREST

MAN

Real-time or Offline AI-driven decision making



DATA ANALYTICS

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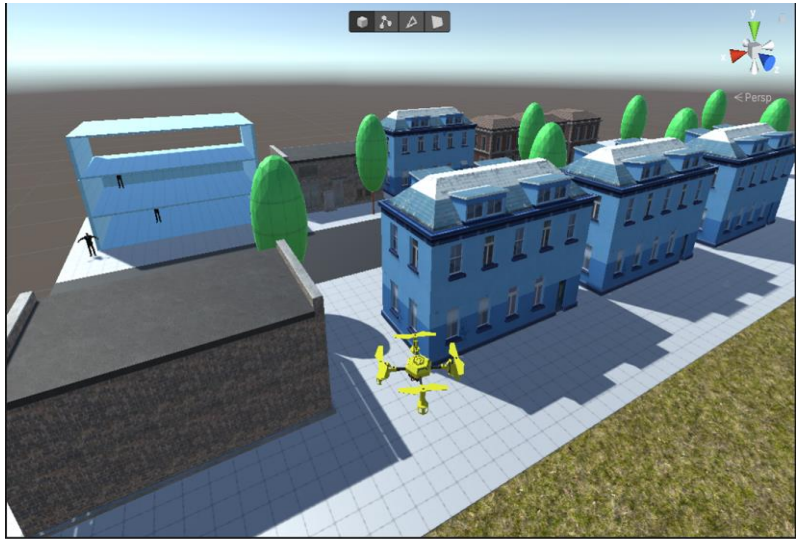
AI/ML dynamic environment simulation

- Active research on Unity environmental design for simulation of various autonomous human-AI interaction scenarios:

- Great for proof-of-study of dynamic environment behaviors

- Unity environment research capabilities:
  - ✓ Interfaces are customizable with external support software for 3D-modelling of environment variables such as buildings terrain, obstacles, weapons,…
  - ✓ Investigate fully/partially autonomous system design, reliability, human-AI trust behaviors,…
  - ✓ AR/VR friendly



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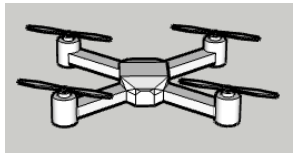
Challenges: AI/ML dynamic environment simulation

DRONES

Player:
Manual mode

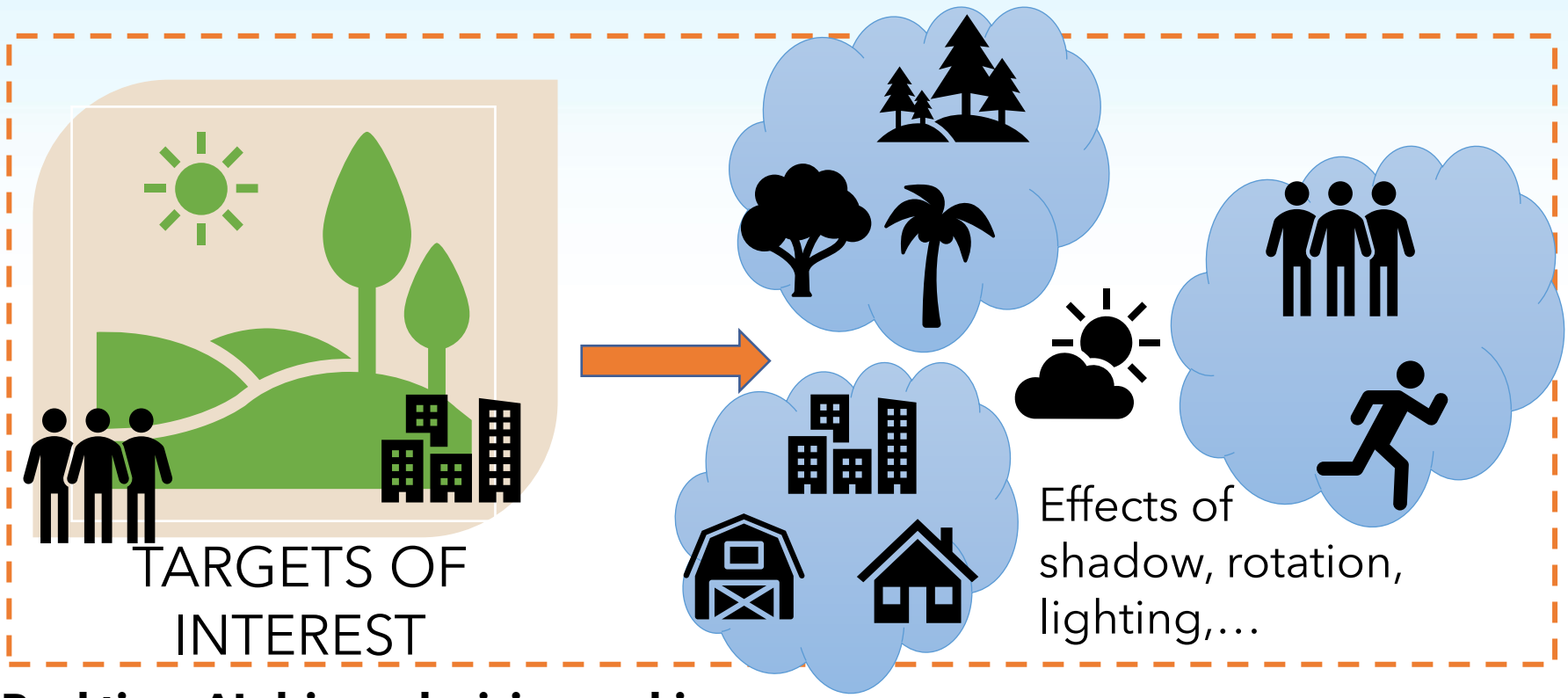


Autonomous mode

TARGETS OF INTEREST

Real time AI-driven decision making

Reliability Challenges: AI/ML dynamic environment detection



Real time AI-driven decision making:

- How to train AI model to identify exhaustive categories of targets of interest?
- What are its implications of AI model training on the reliability of identification of targets of interest in the real world?

Feasibility Challenges: AI/ML-driven autonomous vehicles - Real world

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- Current technological challenges:
  - Intensive hardware requirements (memory and computation) for Big Data processing for UAV-sensor platform-based data collection, data processing and AI/ML driven analyses.
  - Identification of terrain for navigation of drones/autonomous vehicles in challenging environments, e.g. battlefields, disaster-relief scenarios,…, where GPS location information is unavailable.

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Proposed Approach

Solution: Transparent AI/ML decision support systems

→ How does transparent AI/ML decision making support systems empower better understanding of the operational environment and mission success?

→ Can transparent AI/ML decision support system increase user attention through automated identification of filtered 'important' environment entities such as trees, humans, buildings, weapons,…?

→ How does transparent AI/ML decision making support systems improve user interaction with the environment for better situation awareness?

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Experimental Results

- **Evaluation of AI models:** All models were trained on images from ImageNet, Garry's mod, ARMA 3 and Unity simulation environments
- Each object is tested in a scene both with and without a background obstacle

- The below AI models were evaluated in this experiment:
  - VGG-16 with batch normalization
  - ResNet-101
  - Inception V3
  - GoogleNet
  - AlexNet

Experimental Results

Source	Blank Background	Scene Background
Reality		
ARMA 3		
Garrys' Mod		

Experimental Results

Source	Blank Background	Scene Background
Reality		
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Garrys' Mod		

Experimental Results

Source	Blank Background	Scene Background
Reality		
ARMA 3		
Garrys' Mod		

Experimental Results

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Object	Source	Background	VGG16	ResNet101	Inception3	GoogLeNet	AlexNet
couch	real	blank	studio couch 93	studio couch 99	studio couch 99	studio couch 97	studio couch 94
couch	real	scene	studio couch 97	studio couch 99	studio couch 99	studio couch 89	studio couch 99
couch	arma	blank	studio couch 84	studio couch 60	studio couch 91	studio couch 94	studio couch 70
couch	arma	scene	studio couch 27	studio couch 62	studio couch 59	studio couch 49	cannon 17
couch	gmod	blank	studio couch 56	studio couch 97	chest 60	studio couch 37	wallet 24
couch	gmod	scene	patio 18	prayer rug 12	park bench 48	park bench 29	patio 36
desk	real	blank	desk 39	desk 38	desk 99	desk 16	desk 35
desk	real	scene	desk 38	folding chair 64	tripod 67	dining table 76	dining table 33
desk	arma	blank	file 55	desk 98	desk 99	file 45	desk 12
desk	arma	scene	file 88	desk 55	desk 99	desk 32	desk 30
desk	gmod	blank	chest 63	desk 44	desk 56	desk 24	pool table 46
desk	gmod	scene	chest 29	desk 66	crate 63	park bench 12	patio 49
car	real	blank	sports car 62	sports car 59	beach wagon 51	beach wagon 34	beach wagon 71
car	real	scene	sports car 87	sports car 95	sports car 97	sports car 54	sports car 78
car	arma	blank	minivan 83	sports car 51	cab 71	minivan 16	racer 73
car	arma	scene	minivan 58	convertible 39	convertible 57	convertible 37	convertible 39
car	gmod	blank	beach wagon 37	beach wagon 81	beach wagon 95	beach wagon 11	studio couch 38
car	gmod	scene	amphibian 66	pickup 26	amphibian 92	convertible 29	freight car 23
tank	real	blank	tank 99	tank 99	tank 99	tank 98	tank 99
tank	real	scene	tank 99	tank 99	tank 99	tank 97	tank 99
tank	arma	blank	tank 75	tank 98	tank 85	mousetrap 9	tank 23
tank	arma	scene	tank 91	tank 93	tank 99	tank 58	tank 35
tank	gmod	blank	tank 77	tank 92	tank 99	tank 49	half track 97
tank	gmod	scene	tank 89	tank 99	tank 99	tank 92	tank 85

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Conclusions

Feasibility of the use of AI-driven autonomous vehicles are heavily reliant on the applications-specific and the necessary hardware or technology limitations.

Reliability of AI-driven autonomous vehicles or systems have to address domain specific Big Data analyses challenges. The AI models have to be trained on an exhaustive categories of targets of interest for real-world adoption.

Transparent AI/ML system design for decision making in autonomous systems can enhance system reliability and user-trust in the AI-based automated target detection or decision making process.

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Questions???

THANK YOU